Journal of Environmental Management 206 (2018) 123–133

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Cultural dimensions of risk perceptions: A case study on cross-strait driftage pollution in a coastal area of Taiwan

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ARTICLE INFO

Article history:
Received 24 January 2017
Received in revised form
7 October 2017
Accepted 7 October 2017
Available online 20 October 2017

Keywords:
Climate change
Cross-strait driftage
Risk perception
Ethnic group
Coastal area
DPSIR

ABSTRACT

Constant exploitations of the ocean render numerous present challenges as the ocean is linked to human development. The study focused on cross-strait driftage pollution that poses a great threat to coastal environment under climate change. Several hundred packs of herbicides drifting across the Taiwan Strait were discovered along the coastline of Guanyin District of Taiwan. We compared risk perceptions of the local ethnic groups, Hakka and Fulao, residing in a coastal area of Taiwan and exposed to the herbicide coastal incident under climate change. It is of concern that society's response to every dimension of global climate change is mediated by culture. The Driver–Pressure–State–Impact–Response (DPSIR) cause-effect framework was applied in semi-structured interviews to explore coastal sensitivity and human adaptability. As a result, we indicated that despite the presence of two ethnic groups in the same place exposed to the incident they presented very different risk perceptions on both environmental degradation (ED) and adaptive capacity (AC) due to cultural values. We argued that the herbicide coastal incident involved people's risk perceptions and subsequently influenced their opinions and attitudes towards environmental problems. We concluded that the ethnic trait contributed to adaptive behaviors during environmental change. Culturally appropriate adaptations appeared to enhance risk perceptions and adaptation actions, suggesting a need for more rigorous cultural adaptation guidelines towards climate resilience when designing adaptation interventions for different ethnic groups.

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1. Introduction

The ocean is inextricably linked to human development (Hudson, 2015). It is a habitat and breeding base for countless organisms and provides humans multifaceted functions. Diverse usage patterns have been developed in coastal areas. However, coastal pollution causes natural and living environments to deteriorate, destroys crucial biological habitats, and leads to a sharp decline in marine organisms. Moreover, climate change may increase the environmental risks in coastal areas, which host close land–ocean interactions. Taiwan is surrounded by an ocean abundant with marine resources. The coastline of Guanyin District of Taiwan holds ecologically rich mangroves and precious millennial algal reefs, which have been threatened by severe industrial pollution. In addition to these internal troubles, these natural assets are also faced with external threats. On March 31, 2012, coast guard patrols discovered approximately 20 bags of pesticides and herbicides on Guanyin Beach, hereinafter referred to as the herbicide incident (Fig. 1). We argue that people need to be aware of and adapt to a changing environment to ensure their quality of life. However, risk perception may be incomplete or ignored so that actions cannot be undertaken. That is, a stimulus is present in the environment, not strong enough so that a person could not perceive it; or the person does not pay attention to the stimulus that affects the person's behavior or thought process (Dewey, 2007).

The focus of this study was put on cultural dimensions of risk perceptions on coastal change induced by cross-strait driftage pollution, and in particular the adaptive capacities that enable people to lead meaningful and dignified lives, which are at risk from climate change (Brooks, 2003; Safi et al., 2012; Adger et al., 2013). Risk perception refers to subjective judgment of people about the characteristics and severity of a risk, that is, in this case, waste threats to coastal environments. We underlined that residents' risk perceptions about the coastal change addresses the social amplification of risk on cognitive transformation through a range of groups interested in the risk (Kasperson et al., 1988;

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https://doi.org/10.1016/j.jenvman.2017.10.010
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Fig. 1. Coast guard patrols discovered approximately 20 bags of pesticides and herbicides on Guanyin Beach.

Mitchell, 2008), and such groups will distort aspects of the risk in support of their beliefs and values (Smallman and Weir, 1999). Perception is shaped by attitudes and values that vary widely from culture to culture (Hope and Jones, 2014), and is a series of perceptual and behavioral cycles generated when people interact with environments. It is of concern that actions are always initiated by risk perceptions (Wachinger et al., 2012; Brown, 2013; Mase et al., 2016), and society's response to every dimension of global climate change is mediated by culture (Adger et al., 2013). We underlined the importance of cultural dimensions in adaptive capacity (adaptability) and noted that it refers to a cultural process to achieve resilience and depends on ecological well-being and the extent of dependency on natural resources (Holling, 1973; Smit and Wandel, 2006; Adger et al., 2007; Henley, 2010; Engle, 2011; Nelson, 2011; Colombi and Smith, 2012; Lockwood et al., 2015).

In Methods section we elucidate the ocean drift and its cross-strait coastal pollution incident that had occurred on the Guanyin coastline where the drifting herbicide packages were found and had been reported by the newspapers. We underscored the social amplification of risk (Kasperson et al., 1988). Driver–Pressure–State–Impact–Response (DPSIR) causal framework (EEA, 2007) was used in semi-structured interviews to explore the risk perceptions of respondents on the coastal change in a changing climate. We examined the risk perceptions of two local ethnic groups, Hakka and Fulao residing in the coastal area of Guanyin District, whether they perceived the change thereof differently, and whether ethnic trait is one of the factors influencing risk perceptions. Chiang et al. (2014) indicated that in comparison with the Fulao people, characterizes Hakka's cultural process to achieve resilience in coping with difficult living conditions and is regarded as one of their ethnic characteristics. This argument provides key insights into the cultural differences with which most people mark the Hakka.

As a result, we indicated that the perceptions of local Fulao residents (F-residents) and Hakka residents (H-residents) on environmental degradation (ED) were identical. The H-residents presented the best human adaptive capacity (AC). None of F-residents presented positive risk perception while H-residents presented positive risk perceptions. Ethnicity was found as key in guiding perceptions of the respondents in terms of cultural perception. In Discussions section, it is noted that the environmental impact of the herbicide incident refers to people's awareness and perceptions of environmental change, and the adjustments they make, that is their adaptive capacities to maintain and ensure a satisfactory environmental quality. Conclusions section summarizes the insights of this paper, concludes with a perspective on the risk perceptions among local population, and proposes recommendations for ameliorating cross-strait coastal pollution. It is argued that human risk perceptions and behaviors are inseparable portions of the coupled human–environment system.

2. Methods

2.1. Cross-strait driftage

The aforementioned herbicide incident was traced back to the event that a ship ran aground and sank off the coast of Fuzhou on March 15, 2012, when 61 containers containing highly toxic and hazardous caustic soda and herbicides dropped into the ocean. A computer-simulated experiment indicates the incident is referred to the cross flows in the Taiwan Strait and the strengths and variation of northeast monsoons affect the directions of the cross-strait flows (Oey et al., 2014) and may refer to climate change. That is, the herbicide incident occurred during the season of northeast monsoon in the coastal areas of Taoyuan County and climatic factors may increase the variability of similar cross-strait pollution incidents. An annual investigation conducted by the Taiwan Environmental Information Center (2013) on 338 coastal points in Taiwan indicated that the coastline conditions of Taiwan obtained the poorest ratings in industrial effluent and marine debris items. This result revealed the severe impact of marine debris on coastal environments, which was the focus of this study.

Based on the point of origin of the herbicide packages and scientific simulation results regarding ocean drift, cross-strait ocean drift from China may have occurred in the coastal area, under climatic influences, where the herbicides were found, exposing the coastal area of Guanyin District in Taiwan to risks of cross-strait pollution. The perceptions and behaviors of local residents toward climatic change are worth investigating. In particular, Guanyin District is characterized by both Hakka and Fulao culture. We underlined that culture is often closely tied to places that are given meaning by people (Adger et al., 2013). Culture may also be a generator of useful coping strategies in the context of environmental change (Heyd and Brooks, 2009) and can help communities mitigate drivers and pressures in a timely and dynamic manner (Chiang et al., 2014). As climate may influence the coast and the community, we scope the study site, which covered the coastal area (Fig. 2), and provided place suitable for conducting ethnic comparisons on risk perceptions and adaptive capacities of the local residents in a changing climate.

2.2. DPSIR framework

The herbicide incident addressed human–climate interplay that takes place in coastal area and forms risky environment. Analysis applying a causal framework facilitates determining problems in each segment and provides a reference for suitable recommendations and policies for local sustainable development. The Driver–Pressure–State–Impact–Response (DPSIR) causal framework was adopted in the study to explore human-environment interactions focusing on both environmental degradation and human adaptive capacity (Fig. 3; Fig. 4). The DPSIR framework emphasizes that when environmental conditions change, the society must respond to the resulting impacts exerted on the people and ecologies; finally, humans adapt behaviors to environmental change because of their risk perceptions, thereby mitigating impacts, effectively inducing positive human–environment interactions towards resilience. Positive outcome after experiencing such a risk may be viewed as evidence for resilience (Seery, 2011). The DPSIR

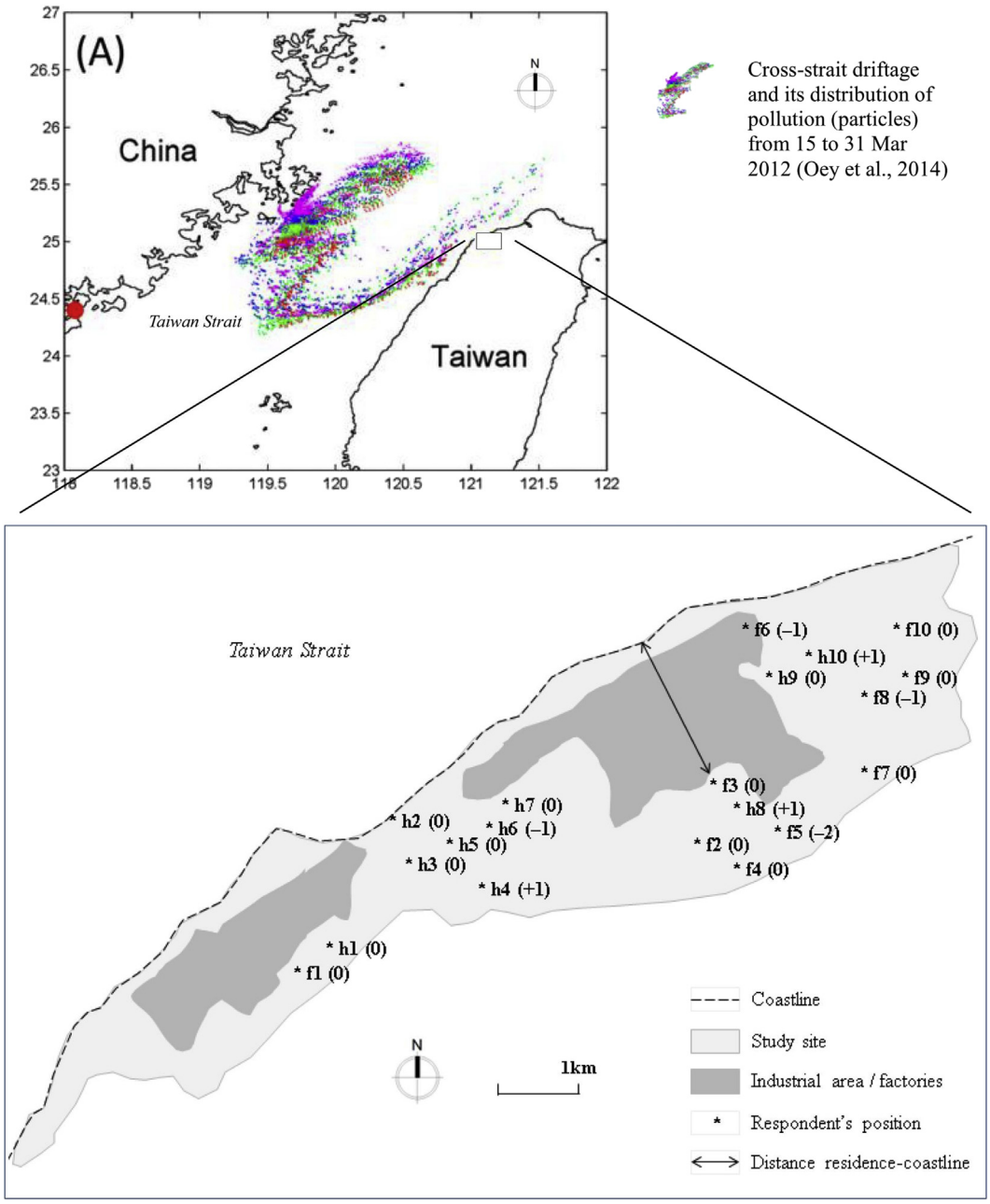

Fig. 2. Study site and the distribution of respondents and their value on risk perceptions to coastal pollution; Google My Maps was used to measure respondents' real distance residence-coastline.

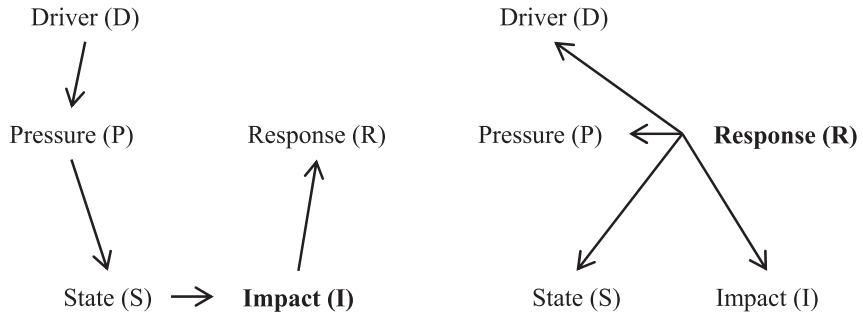

Fig. 3. Exploration of environmental impact (left) and social response (right) in the DPSIR causal framework.

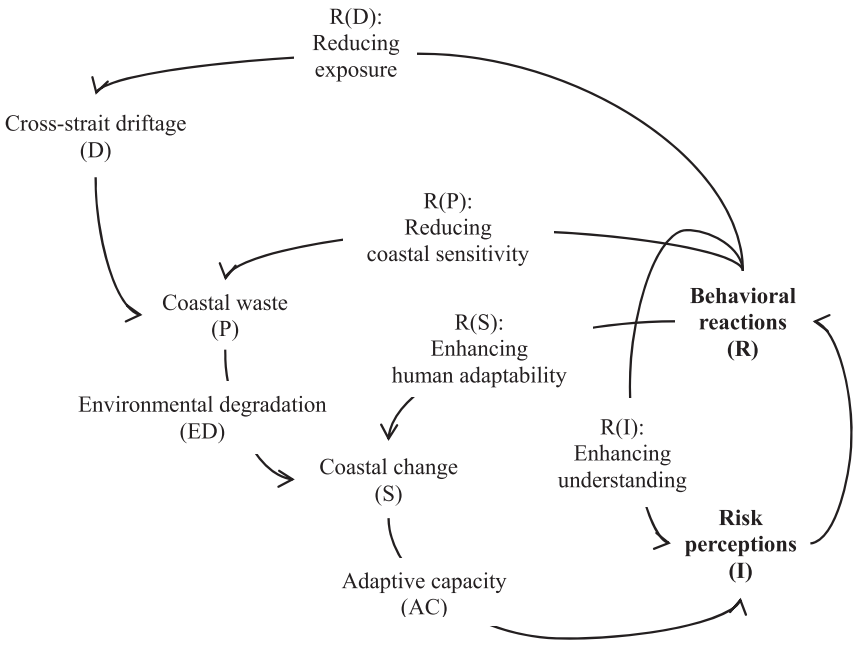

Fig. 4. Risk perceptions and behavioral reactions explored in the DPSIR framework using the vulnerability context: (1) exposure refers to climatic impacts; (2) sensitivity refers to environmental degradation; (3) adaptability refers to adaptive capacity; (4) understanding refers to learning-by-doing.

framework of the study is shown as follows for understanding the cause-effect of the incident:

- *Driver (D)*: In March 2012, a container ship loaded with packages of herbicides and pesticides sank off the coast of China, leaving the toxic packages drifting into the ocean becoming marine debris.
- *Pressure (P)*: Pushed by the ocean current, the wastes drifted across the Taiwan Strait to the Guanyin coastal area, which exposed the local residents to risks of offshore pollution.
- *State (S)*: Interviews were then conducted to determine and compare the awareness of the local residents on the current conditions of environmental degradation and adaptive capacity of the communities.
- *Impact (I)*: Subsequently, the degrees of impact were assessed,
- *Response (R)*: Providing responses to the pollution problems based on actions generated from crisis awareness. Actions were proposed for each segment of the results by observing the risk perceptions of the local residents. Based on these recommendations, local environmental problems may be locally solved. The R consists of *R(D)*: Reducing exposure e.g., controlling the source of pollution, *R(P)*: Reducing sensitivity e.g., reducing coastal waste, and *R(S)*: Enhancing adaptability e.g., elevating environmental awareness.

From the perspective of environmental psychology, the framework explains risk perception as a series of complex psychological processes whereby external environmental messages that people are aware of (information) are transmitted via sensory receptors to the brain where the messages are explained (knowledge). Through the transmission and reception of sensory stimuli, an interactive relationship between people (ethnic groups) and place (physical environment) is established. However, personal social backgrounds vary and perceptual activities are inseparable from personal experience and acquisition; therefore, differing perceptual abilities and experiences induce varying risk perceptions. Investigations on risk perceptions have commonly focused on the correlation between risk perception and spatial behavior. We underscored that people interact with the environment, probe and reevaluate new information, and correct their mental images. Through this recurring process, varying behaviors are generated. In addition, personal attributes and group cultures affect value judgment, which is used as the basis for making decisions and implementing actions. People develop rules of thumb to evaluate the environment, and then constantly accept and correct the evaluation results so that their hazard perceptions can achieve a balance with the environmental operation.

2.3. Vulnerability assessment

The aforementioned framework for analyzing vulnerability facilitates investigating human–environment interactions focused on the status of coastal change: adaptive capacity and environmental degradation (Füssel and Klein, 2006; Vogel et al., 2007; Rounsevell et al., 2010; Romieu et al., 2010), which determine people's risk perception and subsequently their behavioral reactions (Fig. 4). It underlines the “explicate order” of exploration, as in the perception-action cycle (Liljenström, 2011). Recently, environmental impacts resulting from climate changes have progressively increased. In response to the resulting effects on societal development, social vulnerability assessments have become the focus of numerous studies (Cutter, 2003; Adger et al., 2009). We argued that vulnerability primarily involves the risks, impacts, and stresses of disaster exposure under conditions in which the abilities to respond is lacking.

The Intergovernmental Panel on Climate Change indicated that in climate change, vulnerability is the degree to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007). We underscored that adaptive capacity influences risk perceptions, and perceived risk determines the residents' responses (Sjöberg, 2000; Vandeventer, 2012). In the study, the herbicide incident garnered concerns about cross-strait pollution, and scientific evidence has confirmed substantial risks of the incident. As such, exposure refers to the degree of proximity to the incident, sensitivity refers to the

degree of influence of the incident, and adaptive capacity includes the human ability to resist or recover from experiencing incidents. We argued that based on personal experience and degrees of risk perception, the decisions made through adaptation processes and the adaptive behaviors used are all a result of the interconnection and mutual influence existing among people's exposure to climate change, sensitivity to coastal change, and adaptive capacity (adaptability) led by community. The interplay focuses on the response of inherent human traits toward environmental change and how individuals adjust their behavior or social systems to adapt to the environment. Social vulnerability is highlighted and referred to human, under political, financial, and social influences, showing a reduced ability to withstand or recover from risks.

In the context of vulnerability, the DPSIR cause-effect framework was applied in semi-structured interviews to explore coastal sensitivity and human adaptability, the results of which were employed to analyze the respondents' risk perceptions toward cross-strait pollution. The coastal sensitivity refers to the degree of impact of pollution on the environment. These impacts harm and degrade the environment (environmental degradation) and were assigned negative values (−) in the assessment. When people who were exposed to risky environments made unique on-site observations or submitted themselves to other social learning processes thereby developing adaptabilities (adaptive capacities), positive values were assigned (+) (Chiang et al., 2014). That is, the degradation has its minus value whereas the capacity denotes plus performance. In particular, we focused on producing a comparable classification method with regard to the set of indicators, which allows a comprehensive evaluation and comparison of the results (Rannow et al., 2010).

Both environmental degradation and adaptive capacity were addressed using categorical values in three degrees (Table 1). The values are based on three indicators to represent low (1), medium (2) and high (3), and provide a common index that represents the risk perception. It is noted that the risk perceptions address integrated knowledge performance while awareness refers to information collection (Murphy, 2013). The categorical values in three degrees underline another aspect that complicates how people perceive, evaluate, and act on climate change risks, namely the concept of social amplification of risk framework (Kasperson et al., 1988; Hagen, 2015). That is, social and cultural risk amplification processes modify perceptions of risk in terms of risk communication (APA, 2009). It is noted that risks are communicated through different signals that can amplify or attenuate the perception of risks and their manageability (Hagen, 2013). That is, humans have the ability to perceive the incident risk throughout interpretation of sensory information to represent and understand the environment. Based on this, respondents' risk perceptions in the study were calculated and compared as follows:

$$f(x,y) = \mathrm{x} + \mathrm{y} \quad (1)$$

where

Table 1
Dimensions, indicators, and values for vulnerability assessment of the study.

Dimensions of vulnerability	Assessment indicators	Categorical perception values in 3°
Coastal sensitivity	Water, beach, organism	Environmental degradation (ED) −1, −2, −3
Human adaptability	Experience, health, consciousness	Adaptive capacity (AC) +1, +2, +3

x refers to environmental degradation (value) focused on water, beach, and organism (indicator) and is rated from −1 to −3;
y refers to adaptive capacity (value) focused on experience, health, and consciousness (indicator) and is rated from +1 to +3;
f(x, y) refers to the common index that represents risk perception.

The aforementioned water refers to the essential key indicator in the cross-strait pollution incident; and beach refers to the transition area between land and sea, where debris reside between tidal movements. In addition, the Guanyin algal reefs are considered as marine organisms that the respondents have captured or obtained along the seashore, including fish, eel fries, and mollusks etc. Regarding human adaptability, we focused on the aspects of experience, health, and consciousness when people experience environmental change. This facilitated people's abilities to effectively respond to crises (Chiang et al., 2014). These six factors were the primary indicators used in this study for determining the effect of cross-strait pollution on environmental degradation.

- *Awareness*: environmental pollution undoubtedly affects human health; thus, adequate awareness may prevent additional harm. Moreover, environmental problems are complex; if people can develop an awareness of pollution-induced environmental degradation through their insights and judgments, they are considered to demonstrate strengthened personal adaptability.
- *Actions*: Based on the relationship between risk perceptions and behavioral structures, people accept external messages through their senses and intrinsically filter such messages to generate images. Thereby, people produce adaptive behaviors through recurring decision-making–correction processes to attain balance. To acquire insights into the differences in the risk perceptions of residents in the study location, the assessment results and responses thereof were compared for further investigation. The responses in the framework refer to the residents' answers when they were asked whether they were concerned about seaside debris. These responses were rated from *much content, content, slightly concerned, concerned*, to *not concerned.*

2.4. Interview design

Based on the vulnerability concept a semi-structured interview process was conducted using focus groups to determine the respondents' risk perceptions that are related to ethnicity in terms of cultural adaptation under climate change. We underlined that studies that use more than one method require fewer participants, as do studies that use multiple (very in-depth) interviews with the same participant (Mason, 2010; Lee et al., 2002). For this reason, only 20 respondents were included in the study. The semi-structured interview process continued until the respondent either repeated the same answers or was not able or willing to answer (Tools4dev, 2015), each lasting between 20 and 45 min.

To compare the individual risk perceptions in average, the respondents included 10 F-residents, and 10 H-residents, for a total of 20 samples. Local residents in two ethnic groups were compared to reveal the local residents' risk perceptions through multidimensional observation and interpretation. Durations of residency affect people's living experiences, which is pivotal to their risk perceptions. Experiences enable a balance between human perceptions and environmental operations. A major coastal change in Guanyin District occurred during the 1983 Datan cadmium pollution incident; therefore, the respondents who resided in Guanyin District

for approximately 30 years were recruited for this study. The interview locations were selected along two major paths:

- *Along streets*: In investigations on geographic locations, distances from the sources of disaster or pollution are the primary factor influencing risk perception. Drawn by the convenience of transportation, pioneers in the late Qing Dynasty resided along the roads. Kanchuan and Paochang Temples are the centers of faith for the Hakka and Fulao people, respectively. The prosperity of these temples has led to increase in the number of street shops. Therefore, the residents residing in the proximity of the Kanchuan (County Highway 112) and Paochang (Provincial Highway 15) Temples were selected as the respondents.
- *Along streams*: For survival and living convenience, early clans of pioneers in Guanyin commonly resided in the vicinities of streams, puddles, or swamps. Therefore, local residents along streams were also interviewed.

The DPSIR causal framework was adopted to design semi-structured interview questions. The interviews consisted of several key questions that helped to define the areas to be explored and enabled us and the residents to diverge from the interview guide to pursue an idea or response in more detail. Based on the assessment indicators (*water, beach, organism, experience, health,* and *consciousness*) and perception values (−1 and +1), key questions in the semi-structured interview are listed as follows:

- Has the *water* in the coastal area ever been polluted (if answer addresses “water polluted”, note “−1”)?
- Has the *beach* ever been changed? (if answer addresses “beach changed”, note “−1”)
- Has the *organism* ever been destructed (if answer addresses “organism destructed”, note “−1”)
- Have you ever gained *experience* to protect yourself from pollution? (if answer addresses “experience gained”, note “+1”)
- Have you ever concerned about *health* that may be affected by the pollution? (if answer addresses “health concern”, note “+1”)
- Have you ever shared a collective *consciousness* in your neighbor network? (if answer addresses “consciousness shared”, note “+1”)

Google Forms was applied for recording and organizing the questionnaires. The questionnaires were completed during or after the interviews, and the survey responses were directly compiled and presented into the forms. Google Sheets were applied to plot relations to facilitate subsequent analyses. Google My Maps was used to measure respondents' real distance residence-coastline (Fig. 2), add markers to all of the respondent locations, and provide notes on the outlines for each respondent interview, which was then compiled into an exclusive interview map. Furthermore, a scaling function was used for measuring distances to analyze the correlation between the respondents' perceptions and their geographic positions.

3. Results

3.1. State and impacts

The cross-strait pollution problem was included in the DPSIR framework to obtain causal relationships. The format of the table was adapted from Chiang et al. (2014). Cross-strait pollution (D) introduces seaside debris (P), causing environmental stress at the study locations. To determine the impact of such stress on local residents, key information was obtained through interviews with stakeholders regarding current environmental conditions. This information was combined with descriptions on environmental degradations (environmental sensitivity) and current adaptabilities (S) obtained from the interviews. These assessment results represent the respondents' overall risk perceptions (I), which were regarded as their perceived impact, whereas their responses (R) should reflect the impact that they perceived.

According to the assessment factors, the interview records for each respondent (10 H-residents, and 10 F-residents) were converted to positive (+) and negative (−) scores to calculate the numerical values representing each respondent's risk perception. Within the parentheses, negative values indicated that the respondents perceived environmental degradation (ranging from −1 to −3), and positive values indicated the adaptive capacities mentioned by the respondents (ranging from +1 to +3). The variations and analysis results of risk perceptions are presented as follows (Fig. 5; Table 2):

- *Environmental degradation* (ED): Table 2 shows that the perceptions of local F-residents (−22) and H-residents (−22) of environmental degradation (water, beach, organism) were identical. Regarding self-perceived adaptability (experience, health, consciousness), the local H-residents (+24) outscored the local F-residents (+18). Both H-residents (n = 3) and F-residents (n = 4) indicated the worst environmental degradation; There are no residents (n = 0) indicated environmental degradation;
- *Adaptive capacity* (AC): H-residents (n = 4) presented the best human adaptability (+3); the number of residents is higher than the Fulao's (n = 1).
- *Risk perception* (RP): None of F-residents (n = 0) presented positive risk perception while H-residents (n = 3) presented positive risk perceptions; More than half respondents (n = 13, incl. 6 Hakka, and 7 Fulao residents) did not perceive risks; in addition, RP (0) notes that most respondents among all groups (n = 13) have no risk perceptions of the coastal waste. That is, the stimulus is present in the environment, not strong enough so that a person could not perceive it. RP (+) and RP (−) refer to the stimulus that does affect the person's behavior or thought process; strength distribution of group perceptions is consistent with number distribution of positively perceived people. A comparison of the H-residents group (+2) and F-residents group (−4) revealed a difference regarding risk perceptions.
- *Ethnicity*: Ethnicity (Fulao and Hakka) was found as key in guiding perceptions of the respondents in terms of cultural perception. In addition, activities of visitors (insider and outsider) were also addressed to understand their points of view on coastal resource management. Among the local H-residents, the assessment results were similar (variations were slight) and balanced (approached 0), whereas those for the local F-residents approached medium–low scores (0 to −2) and presented comparatively large individual differences. Overall, the local F-residents highly perceived environmental degradation but exhibited low adaptabilities and therefore demonstrated a state of vulnerability (−4). The local H-residents established adequate adaptabilities during environmental change and therefore attained an overall score slightly higher than that for a balanced state (+2).

3.2. Distance and risk perceptions

In addition to the two major study locations, the F-residents exhibited comparatively dispersed residence patterns and resided farther from the coastline than the H-residents did. To avoid assessment results from being influenced by distance factors thus

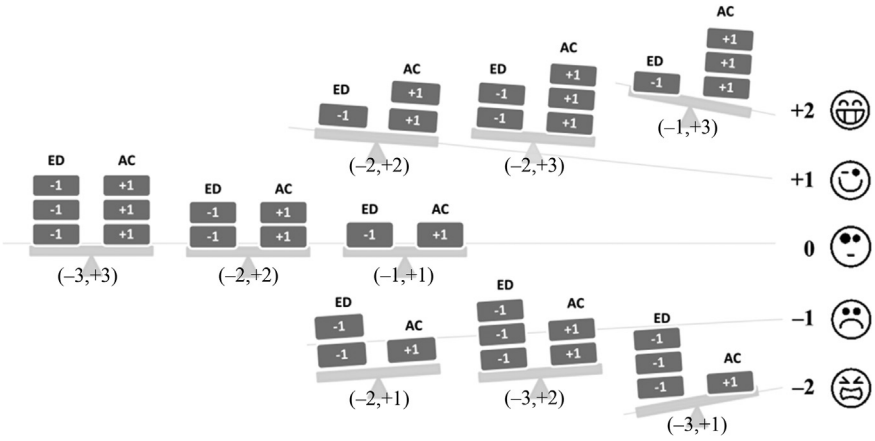

Fig. 5. Perception values related to environmental degradation (ED) and adaptive capacity (AC) are demonstrated as: +2 (much content); +1 (content); 0 (slightly concerned); −1 (concerned); −2 (much concerned).

Table 2
Risk perception s of the respondents based on the assessment indicators (water, beach, organism, experience, health, and consciousness) and perception values (−1 and +1).

Types of samples	Types of perception values (condition) based on ED an AC value	Total value of perception (ED value, AC value)		Backgrounds of respondents		
		H-residents	F-residents	Age	Gender	Occupation
Individuals (20 samples)	+2 (much content)					
	+1 (content)	h4 (−2,+3)		35	Female	Teacher
		h8 (−2,+3)		38	Male	Retailer
		h10 (−1,+2)		40	Male	Engineer
	0 (slightly concerned)	h1 (−3,+3)		48	Male	Fisherman
		h7 (−3,+3)		52	Female	Housewife
		h2 (−2,+2)		45	Female	Babysitter
		h3 (−2,+2)		37	Male	Fisherman
		h5 (−2,+2)		58	Female	Manager
		h9 (−2,+2)		32	Female	Salesman
			f7 (−3,+3)	50	Male	Fisherman
			f1 (−2,+2)	52	Female	Retailer
			f3 (−2,+2)	51	Male	Craftsman
			f4 (−2,+2)	48	Male	Fisherman
			f10 (−2,+2)	46	Female	Housewife
			f2 (−1,+1)	58	Male	Fisherman
			f9 (−1,+1)	56	Male	Technician
	−1 (concerned)	h6 (−3,+2)		60	Male	Fisherman
			f6 (−3,+2)	62	Male	Fisherman
			f8 (−3,+2)	58	Male	Fisherman
			f5 (−3,+1)	65	Male	Retiree
	−2 (much concerned)					
Groups	+2 (much content)	H (−22,+24)				
	−4 (much concerned)		F (−22,+18)			

hindering comparison process, F-residents who are dispersed but resided relatively close to the coastline were selected as the interview respondents. In addition, the geographic distribution of respondents is documented in the map to explore their real distance to coastal wastes and subjective experience that something is close or far away from the self, here, and now, and is related to temporal, spatial, social and hypothetical distance (Trope and Liberman, 2010). As a result, the respondents showed pronounced differences in overall risk perceptions. Distance (degree proximity to disaster locations) is a crucial factor in vulnerability discussions (Chiang et al., 2014). Therefore, the distances from residents' area of residence to the coast (arranged in ascending order) were subsequently analyzed (Fig. 1; Fig. 6.) and described as follows:

- *First segment*: the residents living within ca. 1.3 km (first segment) to the coastline (h2~f10) acquired scores of +/−0 (balanced state: no difference), except for f6 (−1) and h6 (−1) indicating a vulnerable state.
- *Second segment*: the second segment comprised (h4~h8) the residents living 1.4–2.8 km from the coastline. Those who yielded increasing scores (+1) were all H-residents (h4, h10, and h8).
- *Final segment*: the final segment (f7~f4) of residents were the respondents most distant from the coastline (ranging from ca. 3.1–3.5 km). Most of these respondents maintained scores of +/−0. That is, f5 (−2) was the only respondent who achieved score substantially different from that of others (+/−0).
- *Key persons*: f6 (−3) and h6 (+2) in the risk perception assessment indicate that the respondents who were in close proximity to the coastline readily perceived the effect of coastal pollution and demonstrated varying degrees of adaptabilities. However, the adaptabilities were inadequate. f8 (−1) and f5 (−2) demonstrated negative perceptions in relative long distance to coastline even if far away from coastal waste (Fig. 6).

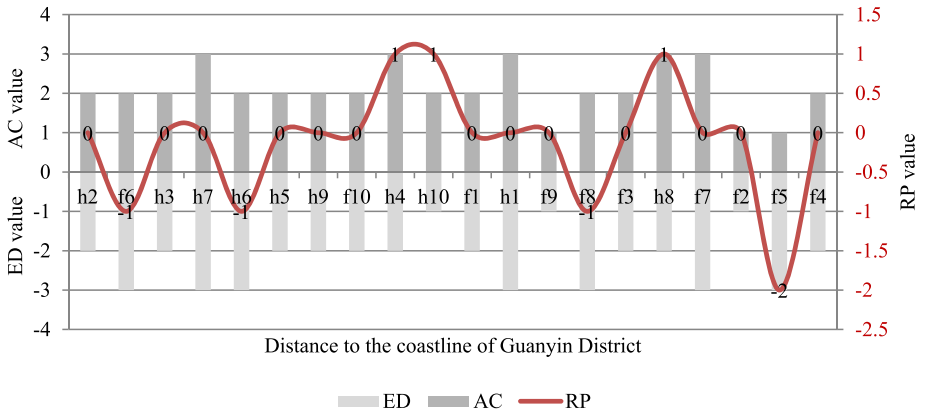
AC value
ED value
RP value
Distance to the coastline of Guanyin District
h2 f6 h3 h7 h6 h5 h9 f10 h4 h10 f1 h1 f9 f8 f3 h8 f7 f2 f5 f4
ED
AC
RP

Fig. 6. Comparison between environmental degradation (EA), adaptive capacity (AC), and risk perception (RP) on the distance to the coastline of Guanyin District: (1) the first segment included the residents (h2~f10) living within ca. 1.3 km to the coastline; (2) the second segment comprised the residents (h4~h8) living 1.4–2.8 km from the coastline; (3) the final segment included the residents (f7~f4) most distant from the coastline (ranging from ca. 3.1–3.5 km).

4. Discussions

4.1. Environmental impact

The environmental impact of the herbicide incident refers to people's awareness and perceptions of environmental change, and the adjustments they make to maintain and ensure a satisfactory environmental quality. Through public awareness, people are strongly inclined toward sustainable lifestyles. That is, effective environmental solutions require not only robust environmental awareness but also physical actions. The human–environment relationship can be perceived differently according to differences in social and human factors, such as lifestyle, life experiences, and values formed by ethnic cultures, hence resulting in varying attitudes and adaptive behaviors.

Recent environmental impact-related studies have increasingly emphasized humanity and social-oriented opinions and demands. However, most studies have adopted quantitative analyses of demographic factors (e.g., age, sex, household income, or education level) and disaster experiences. Moreover, few studies have conducted qualitative interviews and investigated the behaviors of various ethnic groups. Although industrial facilities promote social prosperity and create employment opportunities, a lack of comprehensive supervision and management in the government's pursuit of economic development causes frequent environmental problems. The coastal residents of Guanyin District are constantly experiencing the effect of environmental degradation. Coastal constructions are infringing ecological habitats, and typhoons are accelerating coastal erosion. Consequently, coastal changes may have already posed risks and threats to the living environment of local residents.

The Taiwanese Hakka people exhibit distinct ethnic traits and are skilled at leveraging their wisdom and natural resources to maintain a harmonic lifestyle with nature. When faced with the environmental impacts of adverse incidents, whether the perceptions and adaptability of H-residents are distinct from those of F-residents living along the coastline of Guanyin District is the primary focus of this study and a major contribution to research of related fields. Despite the coastal residents' awareness of the inland threats of industrial effluents in Guanyin, they may be unaware of the potential risks of cross-strait marine pollution. Because the Guanyin coastal area was established since the late Qing Dynasty, the residents have largely maintained the mixed North Fulao–South Hakka living pattern. We addressed the connection between cultural groups and ethnic ones, and linked the development of local expressions of Hakka ethnic awareness to regional specific situations (Leong, 1997).

4.2. Adaptive capacity

Both H-residents (h4, h8, h10) in this study had positive risk perceptions (+1 and +2), indicating their high adaptabilities toward environmental change. This ability–trait enables them to maintain adaptive despite the existence of environmental impacts. The local H-residents who live with the coast demonstrate high cultural adaptability against environmental change. It is of concern that the Hakka people implement a potentially effective response strategy for managing adaptive society in a changing environment (Chiang et al., 2014). We argue that Hakka people strongly value the inheritance of family lineages to future generations; they are remarkably sincere and respectful to their environment, and have defended and fought for their lands, forming an inseparable relationship with their lands. Respondents (f5, f6, f8, h6) who achieved a negative risk perceptions (−1 and −2) presented their concern about the problem of seaside debris, expressing their common concern for the environment. We indicate they were aware of environmental degradation but lacked human adaptability sufficient for them to achieve a balance with the changing environment. Therefore, they were assessed to display a vulnerable state.

On the coastal activities, while most of the non-residents undertake short-term leisure and recreation, the local people take into account sustainable development in the long term. Different ethnic groups address different approaches to cope with changing climate. It looks at how the local knowledge and understanding can help create the resilient environment for climatic and societal change. That is, understanding risk perceptions of climate change is a prerequisite for effective climate communication and adaptation (Carlton and Jacobson, 2013); a better understanding of local risk perception helps to foster prevention and preparedness actions (Rambonilaza et al., 2016). The local knowledge and understanding help to explore iterative adaptation pathways towards climate resilience. That is, different responses are structured in the DPSIR framework and need new inputs throughout societal transformation to avoid mal-adaptation, and case studies are helpful guide the transformation.

4.3. Risk perception

In this study, more than half respondents (n = 13, incl. 6 Hakka, and 7 Fulao) expressed no risk perceptions (0) and thus no concern

about seaside debris. The psychological term of environmental unconsciousness is used to describe the numbness toward the environment. People may neglect other aspects of the environment because of the excessive emphasis they place on one certain aspect and entrap themselves in a state where they become imperceptible to danger. When environmental numbness occurs, people become numb and desensitized in their risk perceptions, exposing themselves to danger. Remarkably, f5 (−2) and f8 (−1) were distant from the seashore but were affected by the impact of seaside debris due to their high negative perceptions (−3) obtained from the assessment results. We argue that these residents rarely visit the seaside and may have indirectly received messages regarding the impacts of seaside debris, thereby engendering their misperception and association to nearby factory pollution. That is, this result was attributed to their misperception. They perceived the severity of industrial exhaust and effluent, which interfered with their images of seaside debris, consequently leading to their high level of risk perception. Specifically, their perceived effects were not truly from coastal pollution but from the noise information of nearby factories. This resulted in their misjudgment of seaside debris. These conditions often occur in senior citizens.

The local F-residents were highly vulnerable to the environmental impact of seaside debris. Risk perceptions form through complex processes because of several factors. As people process messages regarding disasters, their risk perceptions tend to be affected by basic cognitive impairment, individual values, and personal experiences. The local F-residents rarely visited the seashore; consequently, they tend to neglect problems regarding seaside debris because they are so far away from them, they cannot see them and are unaffected by them. In addition, industrial pollution incidents have continuously evaded their lives and affected their sensory perceptions, through news media, visible wastewater, and detectable exhaust. Such information constantly enters into their perceptual systems, prompting them to consider that the impact of industrial pollution on coastal environments is more crucial and detrimental. Perception is the state of mind that people have in identifying, comprehending, and interacting with the environment. When perceiving environmental impacts, adaptive behaviors develop. The influence of experience on risk perceptions and adaptive behaviors emphasizes the importance of personal experience in strengthening and deepening perceptions. The frequency of seaside visits of the local F-residents were noticeably low; therefore, they were unlikely to develop favorable adaptive behaviors.

4.4. Ethnicity

The study addressed how adaptation to climate change in a coastal area of Taiwan is closely related to ethnicity in terms of cultural adaptation. The ethnic trait contributed to adaptive behaviors during environmental change. Culturally appropriate adaptations appeared to enhance intervention relevance, effectiveness, and feasibility, suggesting a need for more rigorous cultural adaptation guidelines when designing adaptation interventions for different ethnic groups (Bender and Clark, 2011).

Ethnicity is a social and psychological process whereby a group of individuals comes to identify some aspect(s) of its culture (Eller, 1997). That is, the culture of an ethnic group is embedded in their lives as experience accumulated for adapting to surrounding environments, embodying the interaction between the ethnic group and the environment. We argued that culture refers to the experience (knowledge and skill) that organisms accumulate during their development process, which reflects their adaptive capacity to changing environments — changing social relations and context that change the meaning of places (Adger et al., 2011). Further, personal experience is emphasized as the most profound source of perception. The influence of experience on risk perceptions includes sources of information experienced through virtual environments, television, and other media. Distancing of experience from the natural world is detrimental to the physical and psychological well-being of people (Kahn et al., 2009; Adger et al., 2011). Various individuals define culture differently. Adger et al. (2007:727) also point to the importance of cultural dimensions in adaptive capacity. Through the processes of transformability, adaptive capacity is a cultural process to achieve resilience (Colombi and Smith, 2012). As culture refers to ethnicity, experience and environment (place), we argue that culture refers to the lifestyle of an ethnic group, its experience and environment. The Hakka culture has the following characteristics:

- *Sustainability*: People who are knowledgeable of the natural environment cherish nature. We argued that environmental problems or sustainable goals must be solved or implemented by enhancing local environmental ethics and consciousness. Through public consciousness, people are strongly inclined toward sustainable lifestyles. Environmental consciousness involves the maintenance of natural spaces that contain all things in existence and the sustainability of future resources.
- *Resilience*: It is noted that the major commonality of Taiwanese Hakka people is their adaptive lifestyle. We proposed how Hakka people's diligence and prudence demonstrate strong resilience and how they adapt to nature, use their wisdom, and overcome adversity by harnessing natural resources, which indicate that Hakka people maintain positive environmental interactions regardless of their locations. We underlined that the lifestyles of the Hakka, often presented in terms of durability, represent community resilience relating to the Hakka culture (Chiang et al., 2014; Ungar, 2011).
- *Feng-Shui*: It is noted that Hakka people conform to the laws of nature and pursue sustainable development through their emphasis on Feng-Shui (Wen, 2011). In the natural environment, people are insignificant. Hakka people present humble and thankful attitudes toward their living environment. Such environmental value derived from their attitudes and cultural concepts, and the beliefs in respect for all things and environmental harmony are all manifested in their living environments and routine habits.

4.5. Climate change

In constantly changing global climates, abnormal weather has become increasingly common, sudden, and difficult to predict. The research location of this study was a coastal area. Climate change is extremely likely to amplify the impact, loss, or harm in coastal areas from seaside debris. The interviews showed that the respondents often mentioned how typhoons increased the amount of seaside debris.

> - “Garbage is plenty after a typhoon. All sorts of trash. Lots of garbage in the sea. Scoop with a net and see. Some buried under the gravel. When typhoons come and stir, everything is uncovered and washes ashore.” (h1)

Typhoons deliver powerful storms and collect inland garbage and substantial drifting marine debris. Therefore, typhoons become a crucial factor that intensifies the internal and external problems of coastal debris. The on-site surveys showed that floats were observed everywhere in the study location. Most of the floats were labeled in simplified Chinese characters specifying the locations or

manufacturers.

- "Those floats! They drift here from distant oceans. We don't understand what it says, unless you are in the business. We did see. They are simplified characters from China. Lots of them." (h1)

- "Floats drifting from China come in various colors. Recycling the black ones is useless. Nobody wants to them. Better to leave them. Twenty years ago it was glass spheres. They can be used for decoration and landscaping. Now, plastic balls are practically useless." (h7)

- "Floats, glass bottles. Trash from China is plenty. They come in two types: old trash is inhabited by organisms, whereas new trash is not." (f7)

These three respondents visit the seashore on a nearly daily basis and were able to observe these drifting foreign objects. Their descriptions provide insights into cross-strait pollution and the degradation thereof.

5. Conclusion

The ocean is a habitat and breeding base for countless organisms and provides humans multifaceted functions. However, constant exploitations of the ocean render numerous present challenges. The focus of this study was put on cultural dimensions of risk perceptions on coastal change induced by cross-strait driftage pollution, and in particular the adaptive capacities that enable people to lead meaningful and dignified lives, which are at risk from climate change. We compared risk perceptions of two ethnic groups, Hakka and Fulao, exposed to the herbicide coastal incident that referred to climate change. It is of concern that society's response to every dimension of global climate change is mediated by culture. We present a novel approach, applying the Driver–Pressure–State–Impact–Response (DPSIR) cause-effect framework and the vulnerability concept in semi-structured interviews to analyze and score risk perceptions, and explore human adaptive capacity to climatic impacts. We indicated that local adaptation to climate change in a coastal area is related to ethnicity in terms of cultural adaptation. Despite the presence of two ethnic groups in the same physical environment exposed to the incident they presented very different risk perceptions due to cultural values. We argued that the herbicide coastal incident involved people's risk perceptions and subsequently influenced their opinions and attitudes towards environmental problems. It is noted that actions are always initiated by risk perceptions.

The interview results revealed that the local Hakka residents were willing to reside by the sea. It is noted that Hakka people develop strong adaptability to environmental change through constant interaction with the environment. In addition, their knowledge regarding climate change must be reinforced to gradually enhance their adaptability to the impacts of environmental changes that will further elevate the overall environmental risks in Taiwan. Furthermore, cross-strait environmental impacts should be appropriately coordinated through communication and negotiation to attain a consensus on global sustainable development for further improving environmental pollution and elevating public environmental awareness. This study underlined the importance of cultural dimensions to how societies perceive, respond and adapt to climate-related risks. Adaptive behaviors are the derivatives and embodiments of climate-related risk perceptions that include the lived aspects of culture and sense of place. Cultural values are ideological concepts acquired through the influence of the environments in which the local residents reside. They regulate and guide individual behaviors and serve as the criteria for taking an action, helping individuals to develop their ultimate preferred behavioral model or lifestyle.

Acknowledgment

The authors would like to thank Pei-Chun Shih for her time in the preparation of this contribution.

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